

CEMP-ET Engineer Technical Letter 1110-3-446	Department of the Army U.S. Army Corps of Engineers Washington, DC 20314-1000	ETL 1110-3-446 20 August 1992
	Engineering and Design REVISION OF THRUST BLOCK CRITERIA IN TM 5-813-5/AFM 88-10, VOL.5 APPENDIX C	
	Distribution Restriction Statement Approved for public release; distribution is unlimited.	

Report Documentation Page		
Report Date 20 Aug 1992	Report Type N/A	Dates Covered (from... to) -
Title and Subtitle Engineering and Design: Revision of Thrust Block Criteria in TM 5-813-5/AFM 88-10, Vol 5 Appendix C	Contract Number	
	Grant Number	
	Program Element Number	
Author(s)	Project Number	
	Task Number	
	Work Unit Number	
Performing Organization Name(s) and Address(es) Department of the Army U.S. Army Corps of Engineers Washington, DC 20314-1000	Performing Organization Report Number	
Sponsoring/Monitoring Agency Name(s) and Address(es)	Sponsor/Monitor's Acronym(s)	
	Sponsor/Monitor's Report Number(s)	
Distribution/Availability Statement Approved for public release, distribution unlimited		
Supplementary Notes		
Abstract		
Subject Terms		
Report Classification unclassified	Classification of this page unclassified	
Classification of Abstract unclassified	Limitation of Abstract UU	
Number of Pages 16		

CEMP-ET

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, D.C. 20314-1000

ETL 1110-3-446

Engineer Technical
Letter No. 1110-3-446


20 August 1992

Engineering and Design
REVISION OF THRUST BLOCK CRITERIA IN
TM 5-813-5/AFM 88-10, VOL. 5
APPENDIX C

1. Purpose. The purpose of this ETL is to provide design engineers with criteria that will be used in preparing designs and project specifications for construction of thrust blocks for underground water and wastewater piping at facilities for the Army and the Air Force. This ETL promulgates, as well as supplements, criteria found in HQUSACE Architectural and Engineering Instructions, Design Criteria, and shall be compatible with and reflect criteria found in Air Force Manual AFM 88-15. This letter is a revision of Appendix C of TM 5-813-5/AFM 88-10, Vol. 5. The enclosed revision should be used for thrust block calculations until the criteria is incorporated into the applicable manual.
2. Applicability. This letter applies to HQUSACE elements, major subordinate commands (MSC), districts, and field operating activities (FOA) having Army and Air Force military construction and design responsibility.
3. Discussion. Appendix C of TM 5-813-5/AFM 88-10, Vol 5, Titled: Water Supply, Water Distribution, incorrectly used bearing capacity in calculating the lateral restraint for thrust blocks. In another part of Appendix C, the use of full passive pressure was incorrectly used to calculate the lateral restraint for thrust blocks.
4. Implementation. This letter will have routine application as defined in paragraph 6C, ER 1110-345-100.

FOR THE DIRECTOR OF MILITARY PROGRAMS:

Encl


RICHARD C. ARMSTRONG, P.E.
Chief, Engineering Division
Directorate of Military Programs

APPENDIX C

THRUST RESTRAINT

ETL 1110-3-446
20 Aug 92

C-1. General. Thrust forces occur in waterlines when the pipeline changes directions, changes sizes, or stops. Thrust blocks or restrained joints are used to resist thrust forces. The geotechnical parameters used herein should be developed by a geotechnical engineer.

C-2. Thrust Forces. The magnitude of the thrust force may be calculated by:

$T = 2PA \sin \phi/2$ at bends;
or by:

$T = PA$ at deadends, branches, or tees.

Where,

T = thrust force in pipe,

P = internal pressure of pipe,

A = internal cross-sectional area of pipe, and

ϕ = angle of deflection of bend.

These are shown in Figures C-1, C-2 and C-3.

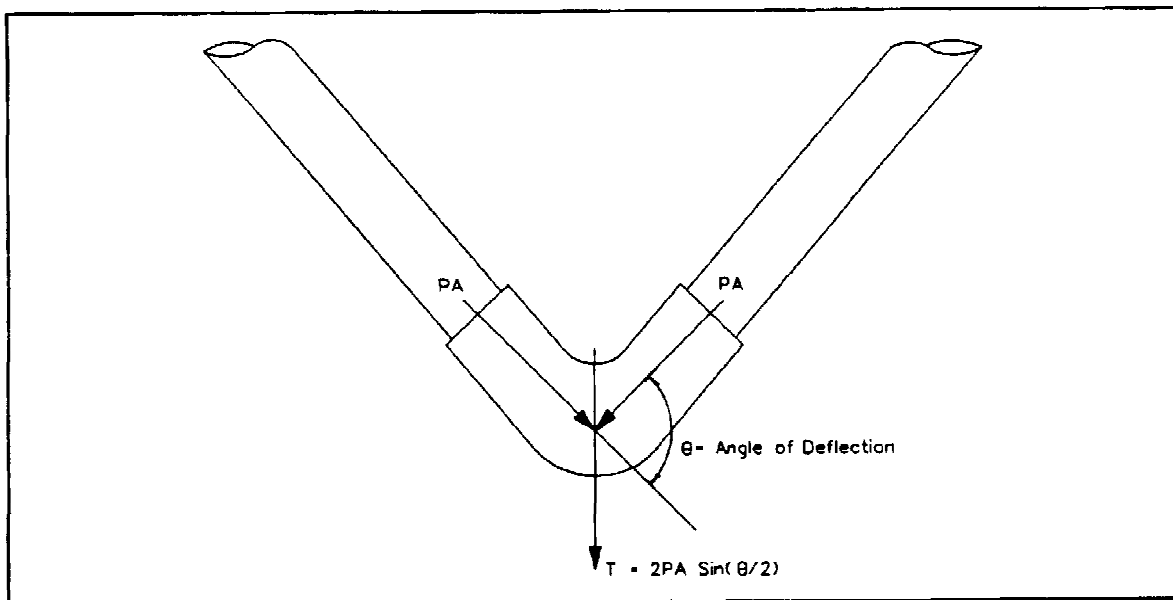


Figure C-1

20 Aug 92

C-3. Thrust Blocks for Horizontal Bends. Refer to paragraph C-7 for sketches. The size of thrust block is calculated by;

$$A_{TB} \geq F_S [T - f(W_S + W_{TB})] / (\gamma_s Z R K_P)$$

where;

A_{TB} = area of thrust block,
 T = thrust force in pipe,
 f = friction coefficient for concrete cast on soil; varies with type of soil; refer to Table C-1,
 W_S = weight of backfill,
 W_{TB} = weight of thrust block,
 γ_s = unit weight of soil,
 Z = embedment depth to bottom of thrust block,
 R = reduction factor applied to K_P (reference 4),
 F_S = factor of safety,
 K_P = coefficient of passive pressure for undisturbed soil of trench sidewall, preferably determined using the log-spiral method (reference 4).

In the absence of information regarding maximum allowable displacement of pipe and pipe joints, use K_o instead of RK_P . The above formula is then;

$$A_{TB} \geq F_S [T - f(W_S + W_{TB})] / (\gamma_s Z K_o)$$

where;

K_o = coefficient of at-rest pressure.

For a conservative approach, the term $f(W_S + W_{TB})$ may be neglected resulting in either $A_{TB} \geq F_S T / (\gamma_s Z R K_P)$ or; $A_{TB} \geq F_S T / (\gamma_s Z K_o)$.

C-4. Thrust Blocks for Vertical Bends. Refer to paragraph C-B for sketches.

C-4.1. The size of thrust block for upward directed thrust is calculated by;

$$V_{TB} \geq F_S (T_y - W_w - W_j - W_s) / \gamma_c$$

where;

V_{TB} = volume of thrust block,
 T_y = vertical component of thrust force = $2PA \sin \theta / 2 \cos \theta$,
 W_w = weight of water in joint,
 W_j = weight of pipe joint,
 W_s = weight of soil or backfill over thrust block,
 γ_c = unit weight of concrete, and
 F_S = Factor of Safety.

For a conservative approach, the terms W_w , W_j , and W_s , may be neglected resulting in $V_{TB} \geq F_S T_y / \gamma_c$.

TABLE C-1

Friction Coefficient for Concrete Cast on Soil
(reference 4)

Interface Materials	Friction Coefficient, f
Mass concrete on the following foundation materials:	
Clean sound rock	0.70
Clean gravel, gravel-sand mixtures, coarse sand	0.55 to 0.60
Clean fine to medium sand, silty medium to coarse sand, silty or clayey gravel	0.45 to 0.55
Clean fine sand, silty or clayey fine to medium sand	0.35 to 0.45
Fine sandy silt, nonplastic silt	0.30 to 0.35
Very stiff and hard residual or preconsolidated clay	0.40 to 0.50
Medium stiff and stiff clay and silty clay	0.30 to 0.35

C-4.2. The size of thrust block for downward directed thrust is calculated by;

$$A_{TB} \geq F_s T_y / q_s$$

where;

A_{TB} = bottom area of thrust block,
 T_y = vertical component of thrust force,
 q_s = allowable bearing capacity of soil, and
 F_s = Factor of Safety.

C-4.3. There is also a horizontal component of thrust (T_x) in vertical bends. The sizing of thrust block for the horizontal component is calculated by the same formula used for horizontal bends, except the term T is replaced by $T_x = 2PA \sin \theta / 2 \cos \theta$.

C-4.4. These are shown in Figures C-4, C-5, C-6 and C-7.

C-5. Restrained Joints. There are several approaches to this. They all calculate the length of pipe to be restrained on both sides of the joint. The length to be restrained may be determined by;

$$L \geq F_s (PA \tan \theta / 2) / (F_f + 0.5 R (s \sum K_p D_o))$$

where;

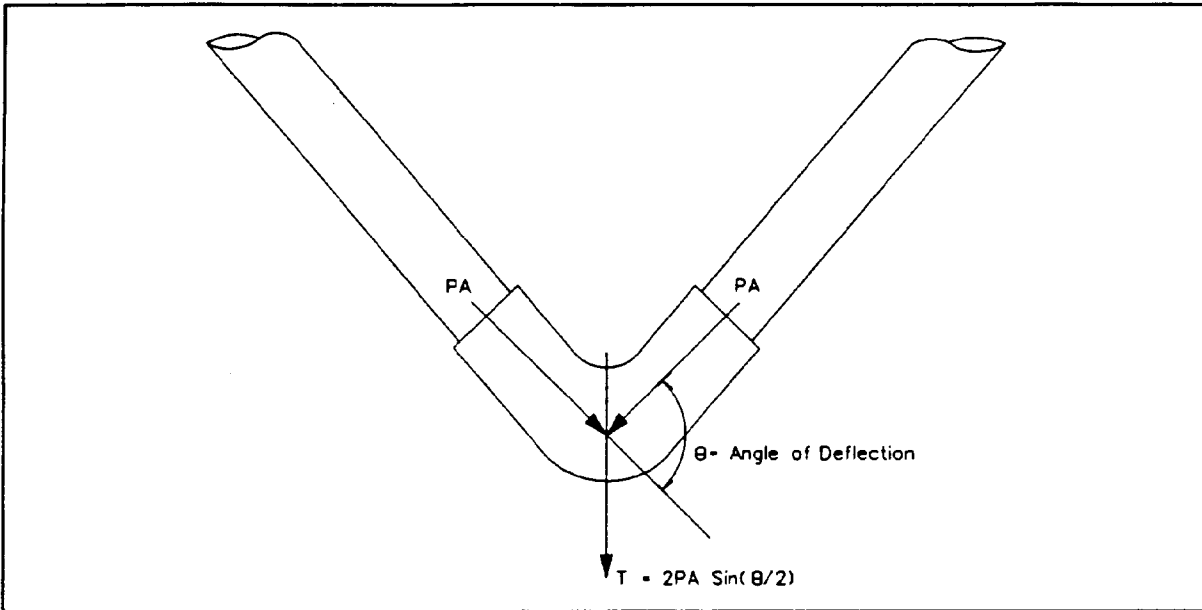


Figure C-4

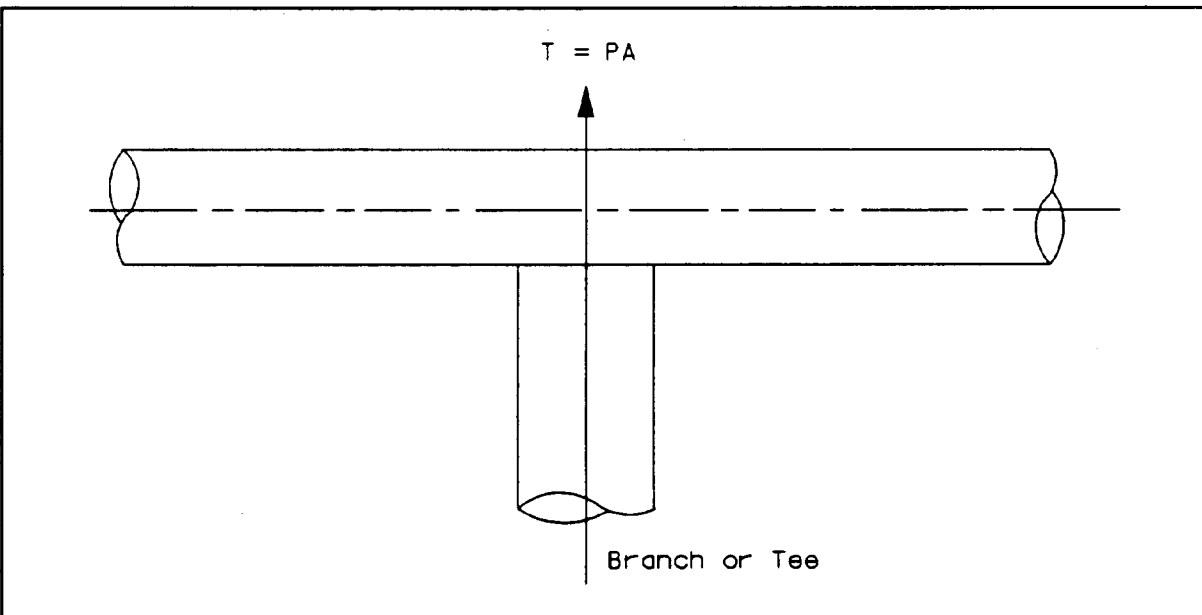


Figure C-5

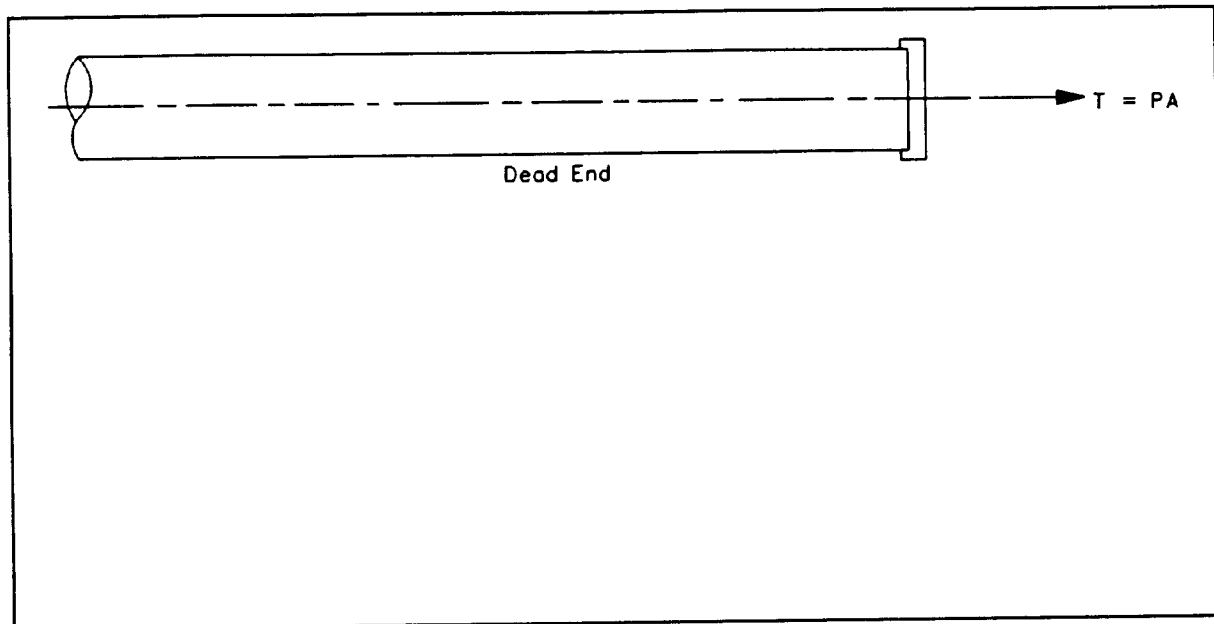


Figure C-6

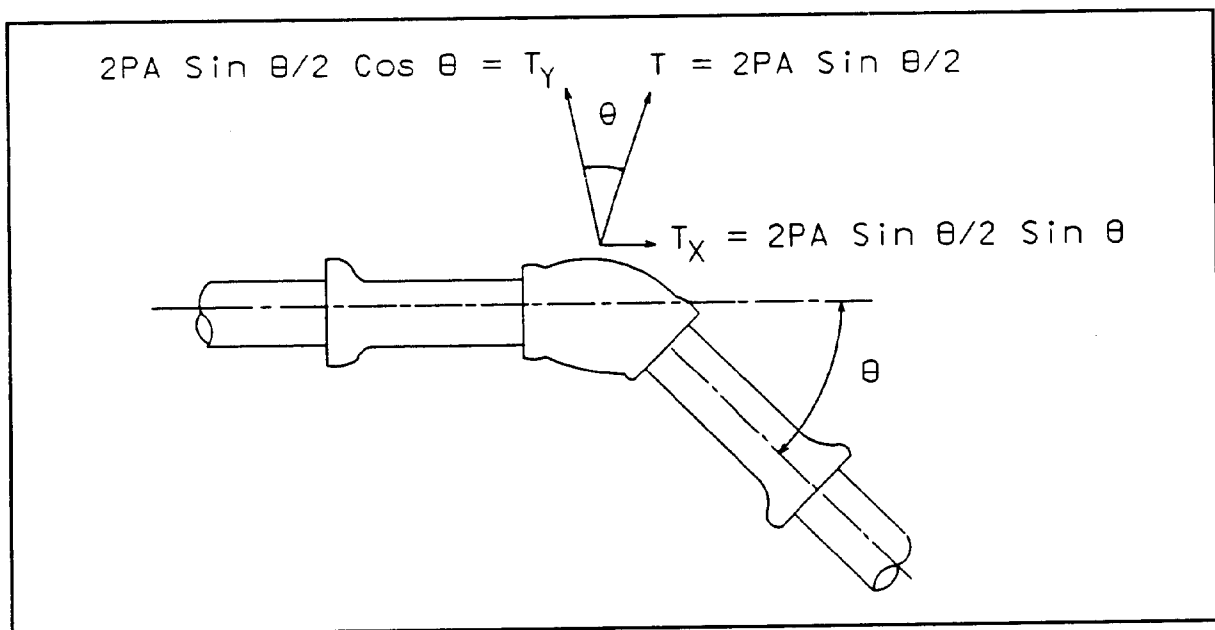


Figure C-7

L = restrained pipe length, one leg,
P = internal pressure of pipe,
A = internal cross-section of pipe,
 θ = angle of deflection of bend,
 F_f = unit frictional force $f(2 W_e + W_p + W_w)$,
R = reduction factor,
(s = unit weight of soil,
Z = depth of embedment,
 K_p = coefficient of passive pressure,
 D_o = outer diameter of pipe,
 W_e = weight of earth on pipe,
 W_p = weight of pipe,
 W_w = weight of water in pipe,
f = as defined in paragraph C-3, and
 F_s = Factor of Safety.

In the absence of information regarding maximum allowable displacement of pipe and pipe joints, use K_0 instead of RK_p . The above formula is then;

$$L \geq F_s(PA \tan \theta/2)/F_f + 0.5 (s Z K_0 D_o)$$

where, K_0 = coefficient of at-rest pressure. If movement is permitted, the reduction factor (R) must be determined by a geotechnical engineer.

C-6. Trenching and Backfilling.

Trenching and backfilling is specified in CEGS 02222 to include bedding, if required, initial backfill to at least one foot above pipe, and final backfill to ground surface. This is shown in Figure C-8.

The backfilling, or laying condition as it is sometimes called, has relevance on the reduction factor (R) used to develop the partial passive soil pressure for the restrained joint conditions. Use only cohesionless materials, if at all possible, as bedding, initial backfill, and final backfill.

C-7. Thrust blocks for horizontal bends are shown in Figures C-9, C-10, C-11 and C-12.

C-8. Thrust blocks for vertical bends are shown as follows. For thrust vertically upward see Figures C-13 and C-14, and for thrust vertically downward see Figure C-15.

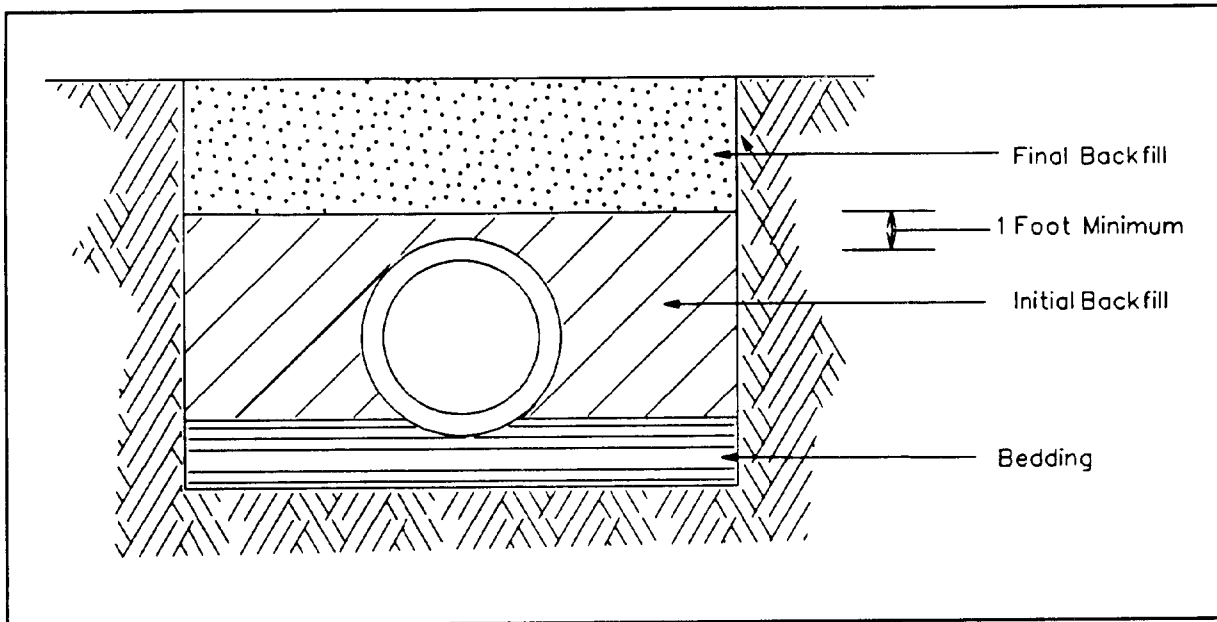


Figure C-8

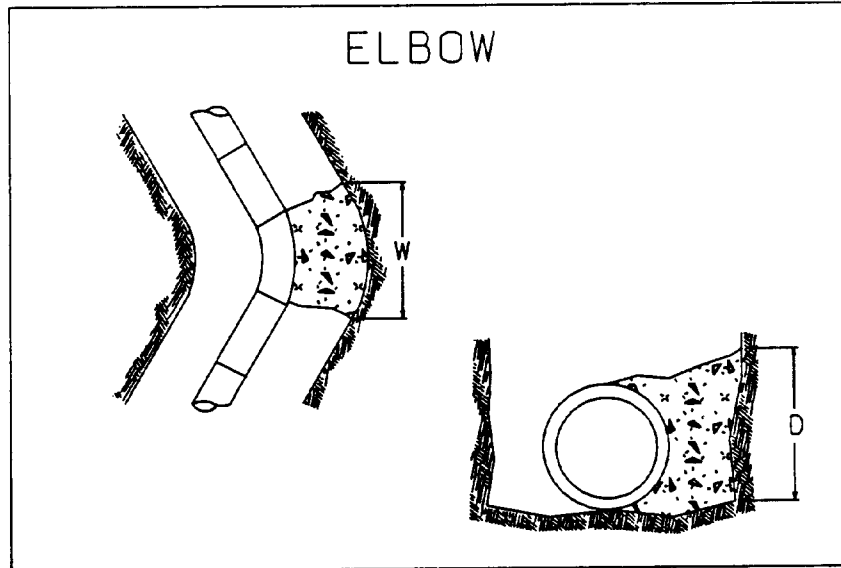


Figure C-9

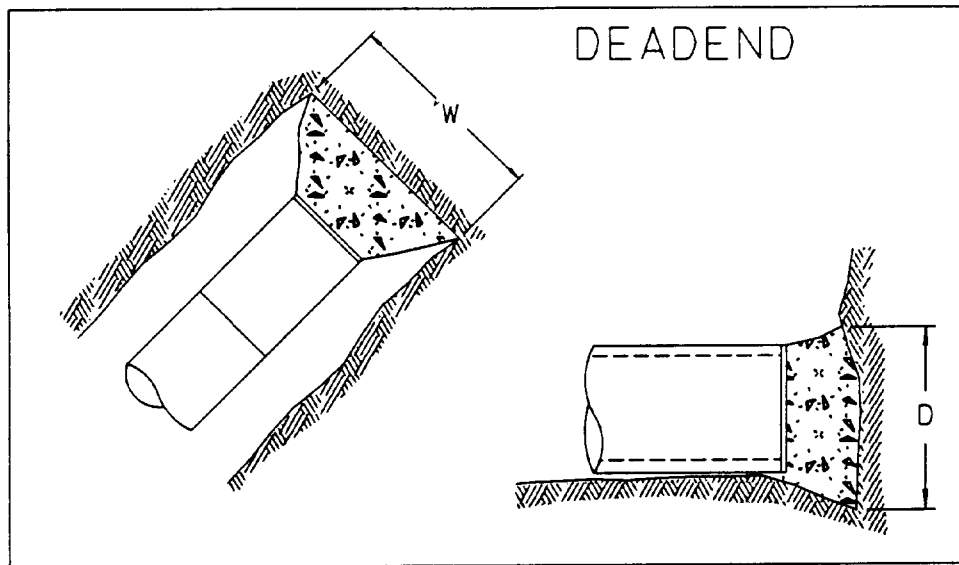


Figure C-10

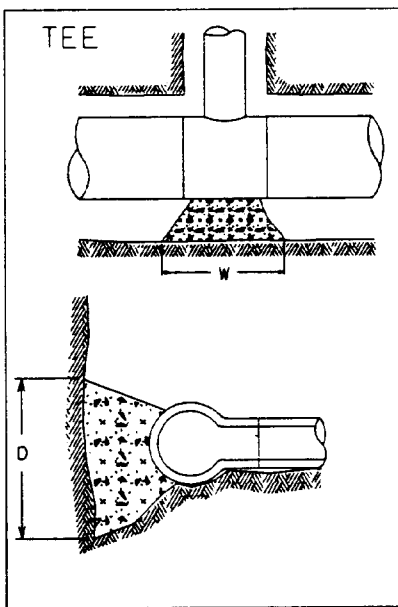


Figure C-11

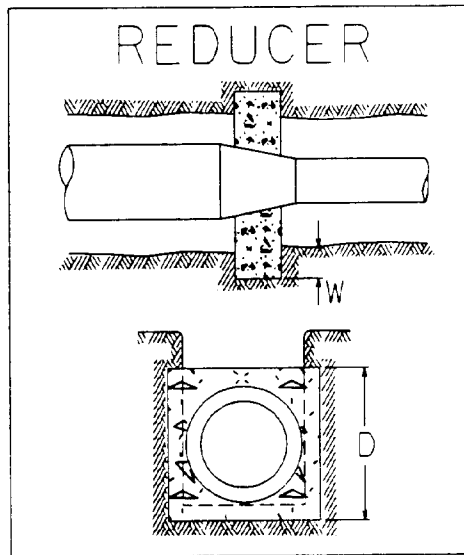


Figure C-12

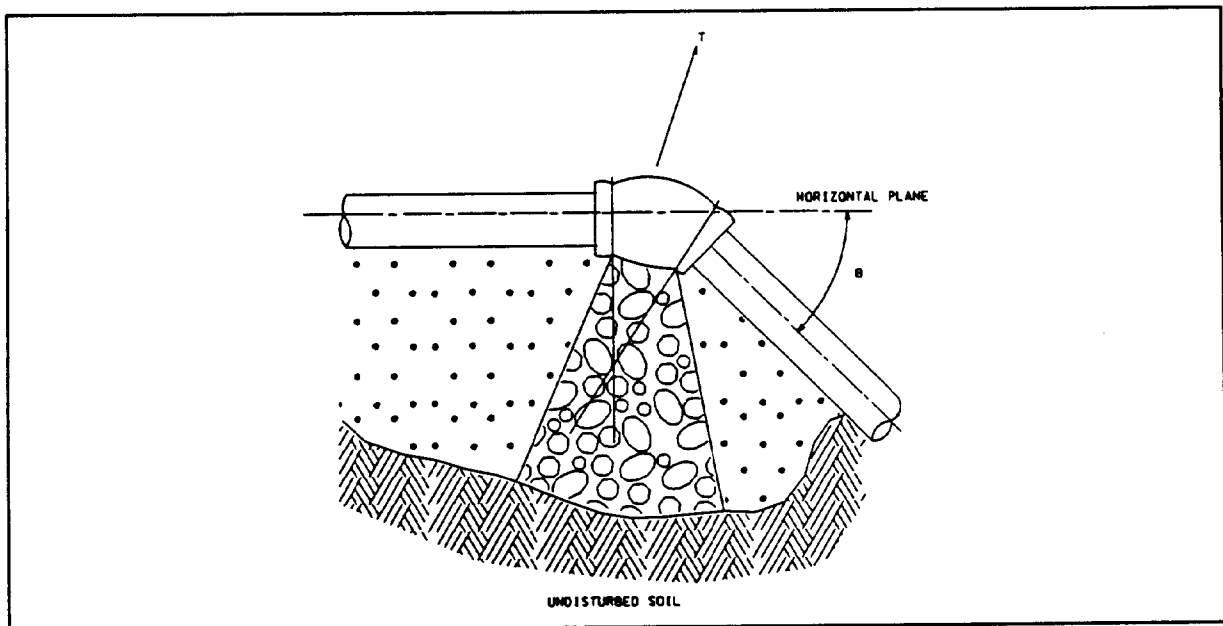


Figure C-13

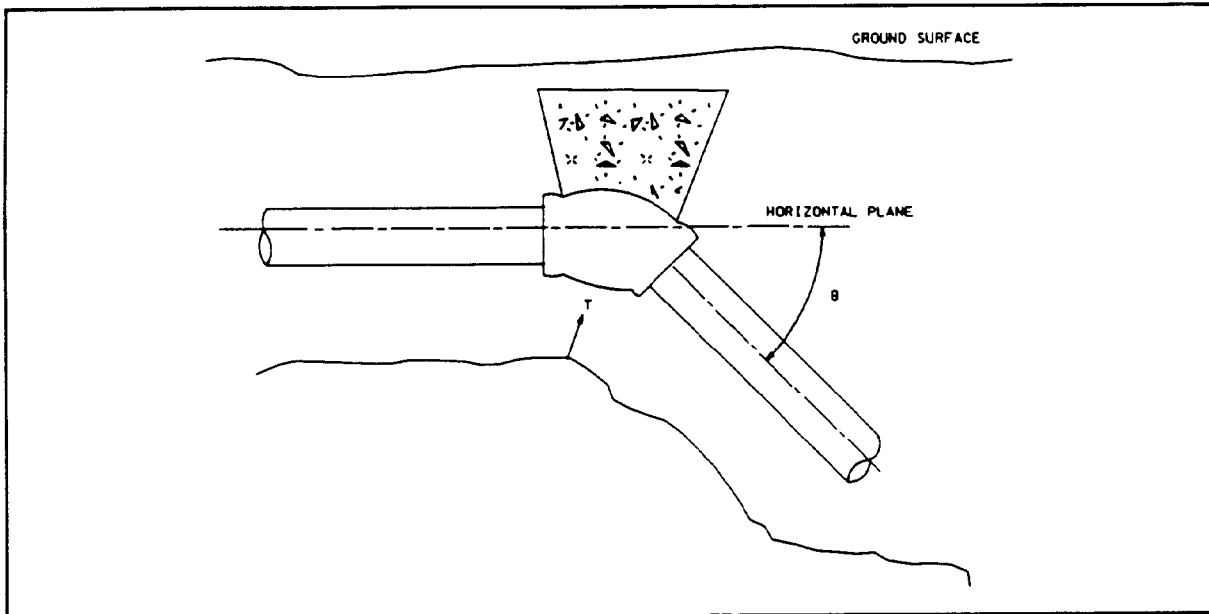


Figure C-14

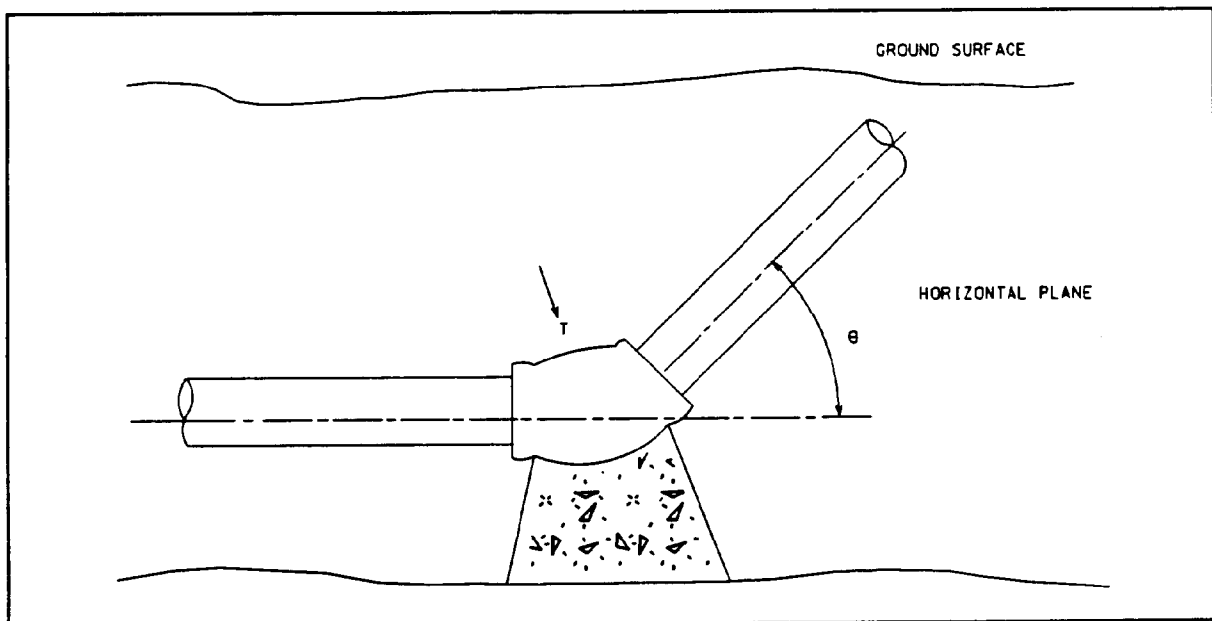


Figure C-15

ETL 1110-3-446
20 Aug 92

C-9. Specifications.

C-9.1. CEGS 02222, Excavation, Filling, and Backfilling for Utilities Systems.

Satisfactory materials for all but final backfill should consist of any cohesionless material (i.e., GW, GP, SW, and SP) as classified by ASTM D 2487, Standard Test Method for Classification of Soils for Engineering Purposes. Limit all material to 3 inches or smaller. Unsatisfactory materials should include all and any material not listed as satisfactory. Select granular material should consist of only satisfactory material classified as GW or SW, natural or crushed, or crushed slag.

C-9.2. CEGS 02660, Water Lines.

Incorporate the guidance of this Appendix (i.e., Appendix C) into the paragraphs relating to Thrust Restraint.

REFERENCES

1. American Cast Iron Pipe Company, American Pipe Manual, Sixteenth Edition, Birmingham, AL, 1986.
2. Carisen, Roger J., "Thrust Restraint for Cast Iron Piping Systems," Public Works, March, 1971.
3. Certain Teed, PVC Piping Systems, Valley Forge, PA.
4. Department of the Navy, Naval Facilities Engineering Command, Foundations and Earth Structures. Design Manual 7.2, Chapter 3, Alexandria, VA, 1982.
5. Ductile Iron Pipe Research Association, Thrust Restraint Design for Ductile Iron pipe, Second Edition, Birmingham, AL, 1989.
6. Duncan, J.M. Unpublished Notes from CE 5520, Earth Pressures, Department of Civil Engineering, Virginia Tech, Blacksburg, VA, 1985.
7. Headquarters, Department of the Army, Guide Specification for military Construction, CECS 02732, Force Mains and inverted Siphons, Washington, D.C.
8. Headquarters, Department of the Army, Guide Specification for Military Construction, CECS 02222, Excavation, Trenching, and Backfilling for Utilities Systems, Washington, D.C.
9. Headquarters, Department of the Army, Guide Specification for Military Construction, CECS 02730, Sanitary Sewers, Washington, D.C.
10. Headquarters, Department of the Army, Guide Specification for Military Construction, CECS 02660, Water Lines, Washington, D.C.
11. Headquarters Departments of the Army and the Air Force, Technical Manual No. 5-818-1, Soils and Geoloav Procedures for Foundation Design of Buildings and Other Structures, Washington, D.C., October 1983.
12. Headquarters, Department of the Army, Technical Manual No. 5-813-5, Water Supply. Water Distribution, Appendix C, Washington, D.C., November 1986.
13. Johns-Manville, Blue Brute Installation Guide, Denver, CO.
14. Kennedy, H., Shumard, D.D., and Meeks, C.M., Ductile Iron Pipe Thrust Restraint Design Handbook, EBAA Iron, Inc., Eastland, TX.
15. Meyerhof, G.G., "Penetration Tests and Bearing Capacity of Cohesionless Soil," Journal of the Soil Mechanics and Foundations Division, ASCE, No. SM1., 1956.
16. Myerhoff, G.G., "Shallow Foundations", Journal of the Soil Mechanics and Foundation Division, ASCE, No. 5M2, 1965.

ETL 1110-3-446
20 Aug 92

17. Peck, R.B., Hansen, W.E., and Thomburn, T.H., Foundation Engineering, John Wiley and Sons, Inc., 2nd Edition, 1974.

18. Price Brothers, Concrete Pressure Pipe Engineering Manual, Eighth Edition, Dayton, OH.

19. Sowers, George F., Introduction to Soil Mechanics and Foundations: Geotechnical Engineering, Chapter 9, Fourth Edition, MacMillian Publishing Co., Inc., New York, 1979.

20. U.S. Pipe and Foundry Company, The Use and Application of Restrained Joints for Ductile Iron Pipelines, Birmingham, AL, 1989.

21. Wu, Tien Hsing, Soil Mechanics, Chapter 10, Allyn and Bacon, Inc., Boston, 1976.